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Estimated cost of diabetic wound care in primary healthcare facilities using the time-driven activity-based costing method

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Abstract

Purpose: This study aimed to estimate the unit cost of diabetic wound care services in primary healthcare facilities (FKTPs) using the Time-Driven Activity-Based Costing (TDABC) method and to quantify the potential cost savings from reallocating cases from secondary (FKRTL) to primary care facilities. **Methods:** A micro-costing analysis was conducted across 40 FKTPs in Indonesia using a standardized five-step TDABC framework, covering personnel, facility, medical supplies, and overhead costs. Descriptive and nonparametric statistical methods, including the trimmed mean, geometric mean, and interquartile range, were applied to derive cost estimates, and simulations with 15% and 35% case shifting from FKRTL to FKTP were performed. Non-parametric methods (Kruskal–Wallis and Mann–Whitney U) were applied because the cost data were not normally distributed. **Results:** The estimated unit cost per diabetic wound-care visit ranged from IDR 67,121 (best-case scenario) to IDR 77,189 (realistic scenario). Cost-shifting simulations projected potential savings of up to IDR 28.15 billion in the 35% scenario. **Conclusion:** Strengthening diabetic wound-care services at the primary care level may enhance system-wide efficiency and reduce avoidable expenditures within the National Health Insurance (JKN) scheme, supporting the adoption of more cost-effective service delivery models in Indonesia.

Keywords: cost shifting; diabetic wounds; primary healthcare; TDABC; unit cost

INTRODUCTION

Diabetes mellitus (DM) imposes a substantial clinical and financial burden globally and in Indonesia, where its prevalence continues to increase and contributes significantly to national healthcare expenditure [1,2]. A major driver of these costs is diabetic foot complications, which require prolonged treatment and are associated with recurrent clinic visits, dressing changes, and hospitalization. Under the JKN scheme, expenditures for diabetes and its complications have consistently ranked among the highest outpatient and inpatient claim categories, reflecting persistent inefficiencies in service delivery and referral patterns. Although uncomplicated diabetic wound care can be effectively managed at primary healthcare facilities (FKTPs), a substantial proportion of cases are still referred to secondary healthcare facilities (FKRTLs). Differences partly influence this pattern in provider payment mechanisms: FKTPs operate under capitation, whereas FKRTLs are reimbursed through Indonesia Case-Based Groups (INA-CBGs). The considerable variation in CBG tariffs across hospital classes and ownership structures may unintentionally create

financial incentives that encourage avoidable referrals, increasing overall service costs.

Despite the importance of primary care in managing diabetic wounds, evidence on the actual cost of diabetic wound care provided in FKTPs remains limited [3,4]. Existing economic evaluations in Indonesia and many LMICs have predominantly focused on hospital-based services, where treatment costs are substantially higher [3-5]. Moreover, most previous costing studies rely on traditional cost-accounting methods, which often fail to capture the heterogeneity of clinical activities, variation in treatment time, and resource capacity [3,6,7]. International studies have demonstrated that Time-Driven Activity-Based Costing (TDABC) provides a more accurate and granular approach to healthcare costing by directly linking activity time to capacity cost rates [3,6-8].

To date, no national-level study in Indonesia has estimated the unit cost of diabetic wound care at the primary care level using the TDABC approach, despite its methodological advantages and its rapid application in the international literature [3,6,7,9]. The absence of FKTP-level TDABC evidence represents a critical gap, particularly for tariff development, referral optimization, and policy reforms aimed at strengthening primary care within the JKN financing structure [5-7, 10,11]. To address this gap, the present study estimates the unit cost of diabetic wound care services in FKTPs using a standardized TDABC framework. It evaluates potential cost-saving opportunities from shifting diabetic wound-care cases from FKRTLs to primary care [6,10]. By providing empirical facility-level cost estimates and simulating cost-shifting scenarios, this study provides essential evidence for optimizing resource allocation, strengthening primary care capacity, and supporting the long-term sustainability of the JKN financing system.

METHODS

This study employed a descriptive quantitative design using a micro-costing approach based on the Time-Driven Activity-Based Costing (TDABC) framework. The TDABC method enables cost estimation by linking the time required for clinical activities with the capacity cost rate (CCR), allowing a more precise representation of resource use than conventional costing approaches [6,10]. Data collection was conduct- ed at primary healthcare facilities (FKTPs), including public community health centers (Puskesmas), private clinics, and individual practitioners. Of the 60 purposely selected facilities across five major islands in Indonesia, 40 completed the standardized excel-based costing instrument (modified TDABC tool). The data included activity time, clinical and administrative workflow, staff categories, facility capacity, and total resource expenditures for personnel, facilities, consumables, and overhead.

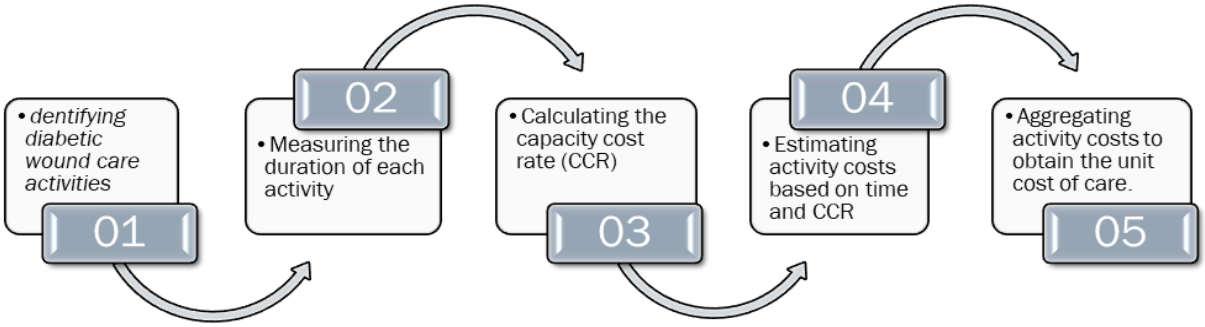

Figure 1. Five stages of the TDABC method

The TDABC implementation followed five methodological stages described in previous literature (Figure 1) [6]. First, all diabetic wound-care activities were identified, including registration, initial assessment, wound examination, treatment procedures, dressing changes, consultations, and documentation. Second, the duration of each activity was measured through direct observation, interviews with healthcare workers, and review of facility Standard Operating Procedures (SOPs), consistent with established TDABC guidance [10]. Third, the Capacity Cost Rate (CCR) for each resource was calculated by dividing total resource expenditure by the practical capacity, defined as 80–85% of total annual adequate working time [10]. Fourth, activity costs were estimated by multiplying the measured activity duration by the CCR. Finally, all activity-level costs were aggregated to generate the unit cost of a single diabetic wound-care visit.

Operational definitions of the study variables were established to ensure consistency in the costing and analysis process. “Type of facility” refers to three categories of primary healthcare providers: public community health centers (Puskesmas), private clinics, and individual general practitioners. “Personnel cost” represents the monetary value of staff time allocated to diabetic wound care activities, calculated using the

capacity cost rate (CCR). "Facility cost" includes depreciation and operational expenses for rooms, treatment spaces, and medical equipment used in wound care. "Overhead cost" captures indirect expenses such as utilities, administrative support, and non-clinical operations allocated proportionally through CCR. "Drugs and disposable medical supplies" encompass all consumables directly used during wound care procedures. "Unit cost" denotes the aggregated cost of all activities required for a single diabetic wound care visit. For statistical estimation, the trimmed mean (TM) represents the mean after excluding the lowest and highest 10% of values, the geometric mean (GM) reflects the multiplicative average suitable for non-normal data, and the interquartile range (IQR) describes the distribution spread between the 25th and 75th percentiles [5,12]. For the cost-shifting analysis, "FKTP visits" refer to the expected number of primary care wound care encounters, while "FKRTL visits" and "FKRTL claims" refer to hospital-level outpatient encounters and their corresponding INA-CBG reimbursement amounts. These operational definitions guided the interpretation and comparison of results across facility types and costing scenarios.

Data were analyzed using both descriptive and inferential statistical methods. Descriptive statistics, including median, mode, trimmed mean, geometric mean, and interquartile range, were used to summarize the distribution of unit cost components. Before conducting inferential tests, the data were assessed for normality. The Shapiro–Wilk test was applied due to its suitability for small to moderate sample sizes, and visual inspections using histograms and Q–Q plots were performed to assess normality.

Because the cost data were non-normally distributed, as indicated by the Shapiro–Wilk test and Q–Q plot, parametric procedures such as the independent-samples t-test or one-way ANOVA were not appropriate. In addition, the primary healthcare facilities were classified into three independent categories: public community health centers (Puskesmas), private clinics, and individual general practitioners, which represent the standard structural typology of FKTP in Indonesia. Since comparisons involved more than two groups, the independent t-test could not be used, as it is restricted to two-group comparisons. The one-way ANOVA was also unsuitable because the data violated the normality assumption required for parametric analysis. Therefore, differences in cost components across FKTP categories were examined using the Kruskal–Wallis test, the recommended non-parametric alternative for multi-group comparisons under non-normal conditions, followed by Mann–Whitney U tests for pairwise comparisons. This analytical approach ensures alignment between statistical methods and the empirical characteristics of the data, directly addressing the reviewer's concerns.

All statistical procedures were conducted using IBM SPSS Statistics version 26, which was employed for the Shapiro–Wilk normality test, Q–Q plot inspection, and non-parametric analyses, including the Kruskal–Wallis and Mann–Whitney U tests. Descriptive measures, including the median, mode, trimmed mean, geometric mean, and IQR, were also generated in SPSS. Costing computations, including capacity cost rate (CCR) estimation, activity-based aggregation, and descriptive cost modeling were performed using a Microsoft Excel 365-based TDABC instrument developed for this study. A significance threshold of 0.05 was applied for all inferential tests.

Moreover, cost-shifting simulations were conducted using scenarios of 15% and 35% from the FKRTL visit number of diabetic wound care in 2023, as expected for the FKTP visit number. By multiplying the expected number of FKTP visits by the unit cost of diabetic wound care in FKTP, we obtain an estimation of FKTP expenditure for diabetic wounds in FKTP. The difference between the estimated costs at FKTP and FKRTL for total outpatient diabetic wound care claims in 2023 is considered a cost-shifting simulation result. Furthermore, the cost savings from relocating the diabetic wound care service from FKRTL to FKTP will serve as a policy recommendation for NHI health services.

RESULTS

This study analyzed diabetic wound-care unit costs across 40 FKTP facilities, comprising 25 Puskesmas, 11 private clinics, and four individual practitioners. Differences across FKTP categories were examined using the Kruskal–Wallis test because the data were non-normally distributed and involved more than two facility types.

Table 1. Results of the Kruskal–Wallis Test for differences in cost components across FKTP types

Cost Component	p	Significance
Personnel	0.9274	Not significant
Facilities	0.1037	Not significant
Overhead	0.0805	Not significant
Drugs & disposable medical supplies	0.1940	Not significant

Note: p (p-value); n = 40; $\alpha = 0.05$.
No significant differences among FKTP types

As shown in Table 1, there were no statistically significant differences in any of the cost components among the three FKTP categories (personnel cost p =

0.9274; facility cost p = 0.1037; overhead cost p = 0.0805; drugs and medical supplies p = 0.194). These findings indicate that the FKTP data can be analyzed as a consolidated population for subsequent costing estimations.

The unit cost estimation process employed five descriptive statistical measures: median, mode, trimmed mean, geometric mean, and interquartile range were used to summarize the distribution of unit cost values across facilities [6]. Researchers used trimmed means to reduce the influence of extreme values (outliers) and can perform optimally in the presence of heavy-tailed distributions by removing a specific percentage of the smallest and largest values. Since the researcher is analyzing non-normal data, the geometric mean is recommended for measuring central tendency.

The IQR describes the distribution of data between the first and third quartiles and effectively isolates the influence of values that deviate far from the data's center. Median and mode values are considered to represent conservative estimates of the population distribution. At the same time, TM, GM, and IQR provide more realistic estimates by accounting for the data distribution and outliers.

As Table 2 demonstrates, the initial calculations show that the estimated unit cost range varies from IDR 110,678 to IDR 184,149, reflecting different assumptions based on FKTP ownership. Puskesmas, as public primary health care, would have a lower unit cost because personnel costs, including civil servant salaries, are not included. In the capitation scheme, overhead, and some drugs and medical supplies were funded by the local government. For private clinics and individual practitioners providing private primary health care, the capitation budget already covers personnel, standard drugs, disposable medical supplies, and overhead and indirect costs. However, this estimated unit cost is an add-on to diabetic wound care and cannot be covered by capitation [3,5].

To generate more accurate and relevant unit cost estimates, adjustments were made by including only variable cost components not covered by the capitation scheme. These adjustments reflect the actual resource consumption attributable to diabetic wound care activities and were applied consistently across all facilities. The adjusted results presented in Table 3 provide a more realistic estimation of the unit cost for diabetic wound care services at the primary healthcare level.

The pre-adjustment unit cost analysis in Table 2 shows variations in total unit cost across five statistical approaches. Drugs and disposable medical supplies account for the largest share of costs. The post-adjustment results in Table 3 show a decrease in all types of estimated costs. The adjusted results, ranging from IDR 87,643 (IQR) to IDR 120,727 (TM), provide more realistic unit costs and can serve as a basis for diabetic wound care tariff settings.

Table 2. Estimated Cost of DM wound care - baseline data (n=40)

Cost component	Median	Modus	TM	GM	IQR
Personnel	35,459	20,601	42,673	35,683	34,525
Facilities	11,281	11,941	16,928	10,921	30,207
Overhead	26,448	12,016	37,797	25,777	53,685
Drugs and disposable medical supplies	66,952	66,120	86,751	82,993	58,931
Total	**140,140**	**110,678**	**184,149**	**155,374**	**177,348**

Note: Trimmed mean (TM) represents the mean after excluding the lowest and highest 10% of values, the geometric mean (GM) reflects the multiplicative average suitable for non-normal data, and the interquartile range (IQR) describes the distribution spread between the 25th and 75th percentiles.

Table 3. Estimated cost of DM wound care - after adjustment (n=40)

Cost component	Median	Modus	TM	GM	IQR
Personnel	25,838	20,601	27,445	35,683	20,923
Facilities	11,281	11,941	16,928	10,921	16,523
Overhead	18,785	12,016	22,544	17,771	26,614
Drugs and disposable medical supplies	56,815	66,120	53,811	50,938	23,583
Total	**112,718**	**110,678**	**120,727**	**115,313**	**87,643**

Note: Trimmed mean (TM) represents the mean after excluding the lowest and highest 10% of values, the geometric mean (GM) reflects the multiplicative average suitable for non-normal data, and the interquartile range (IQR) describes the distribution spread between the 25th and 75th percentiles.

DISCUSSION

This section discusses the implications of the findings and their relevance for primary-care strengthening and JKN efficiency, interprets the patterns observed across cost components, and examines the relevance of significant cost estimates and cost-shifting scenarios for strengthening primary healthcare services and improving the efficiency of the JKN financing system [3,6,7,13]. After estimating unit costs using a descriptive statistical approach, diabetic wound care tariff scenarios were developed using the cost-plus-margin method commonly used for health

service tariffs. The lowest unit cost identified from the costing analysis serves as the base tariff (minimum tariff), with an added margin to accommodate financing flexibility and operational risk.

The minimum tariff was set at the lowest unit cost from the adjusted costing results (IDR 67,121). Furthermore, an average margin of 15% was added to accommodate financing flexibility, operational risk, and improvements in service quality. This method yields two types of tariffs: the best-case tariff and the realistic-case tariff. The best-case tariff represents the most efficient tariff, and the realistic-case tariff accommodates allowance for additional costs. A summary of the estimated tariff is presented in Table 4.

Table 4. Summary of tariff estimation values

Cost Component	Best Case (IDR)*	Realistic Case (IDR)**
Personnel	20,601	23,691
Facilities	10,921	12,559
Overhead	12,016	13,818
Drugs and disposable medical supplies	23,583	27,120
Total	**67,121**	**77,189**

* The minimum value derived from the adjusted descriptive statistical analysis of the costing data distribution
** The maximum tariff is derived by applying a 15% margin to each cost component

Table 5. FKRTL outpatient claims and visits for diabetic wound care in 2023

Class of FKRTL	Tariff of FKRTL		Number of FKRTL Visits		Total Claims of FKRTL	
	Public	Private	Public	Private	Public	Private
A	227,100	238,500	7,432	206	1,687,807,200	49,131,000
B	206,900	217,240	46,691	18,846	9,660,367,900	4,094,105,040
C	195,700	205,500	82,848	13,006	16,213,353,600	2,672,733,000
D	186,160	195,420	12,995	29,152	2,419,149,200	5,696,883,840
Total			**149,966**	**61,210**	**29,980,677,900**	**12,512,852,880**

Source: BPJS Health data, 2024

Table 6. Estimation of cost shifting at 15% of DM wound care visits to primary care facilities

Class of FKRTL	Shifting of visit		Cost Shifting		Cost-Shifting Simulation		Efficiency Estimation		Total
	Public	Private	Public	Private	Public	Private	Public	Private	
A	1,115	31	253,171,080	7,369,650	72,462,000	2,317,500	180,709,080	5,052,150	185,761,230
B	7,004	2,827	1,449,055,185	614,115,756	455,237,250	212,017,500	993,817,935	402,098,256	1,395,916,191
C	12,427	1,951	2,432,003,040	400,909,950	807,768,000	146,317,500	1,624,235,040	254,592,576	1,878,827,490
D	1,949	4,373	362,872,380	854,532,576	126,701,250	327,960,000	236,171,130	526,572,576	762,743,706
TOTAL	**22,495**	**9,182**	**4,497,101,685**	**1,876,927,932**	**1,462,168,500**	**688,612,500**	**3,034,933,185**	**1,188,315,432**	**4,223,248,617**

Table 7. Estimation of cost shifting at 35% of DM wound care visits to primary care facilities

Class of FKRTL	Shifting of visit		Cost Shifting		Cost-Shifting Simulation		Efficiency Estimation		Total
	Public	Private	Public	Private	Public	Private	Public	Private	
A	2,601	72	590,732,520	17,195,850	169,078,000	5,407,500	421,654,520	11,788,350	433,442,870
B	16,342	6,596	3,381,128,765	1,432,936,764	1,062,220,250	494,707,500	2,318,908,515	938,229,264	3,257,137,779
C	28,997	4,552	5,674,673,760	935,456,550	1,884,792,000	341,407,500	3,789,881,760	594,049,050	4,383,930,810
D	4,548	10,203	846,702,220	1,993,909,344	295,636,250	765,240,000	551,065,970	1,228,669,344	1,779,735,314
TOTAL	**52,488**	**21,424**	**10,493,237,265**	**4,379,498,508**	**3,411,726,500**	**1,606,762,500**	**7,081,510,765**	**2,772,736,008**	**9,854,246,773**

Cost shifting of diabetic wound care

This research employed a cost-shifting approach to assess the efficiency of financing gains from diabetic wound treatment from FKRTL to FKTP. A cost-shifting analysis was conducted using outpatient diabetic wound care claims data from the Indonesian NHI in 2023 (Table 5) and estimated unit costs at primary care facilities. The scenario of 15% and 35% of diabetic wound care visits from FKRTL shifting to FKTP. These numbers were used to estimate the prevalence of diabetic wounds in primary health care. The cost-shifting simulation results indicate potential cost savings. There are various outpatient FKRTL tariffs for wound care under the NHI scheme, depending on the region and FKRTL class. The average tariff of INA-CBG for the wound catch group, code Z-3-27-0, was used as the base FKRTL tariff in the calculation. Furthermore, a cost-shifting analysis was conducted using two scenarios: 15% and 25%. FKRTL case to FKTP. This study utilized FKRTL data on diabetic wound care visit numbers and claims in 2023 for a cost-shifting analysis.

The cost shifting from FKRTL to FKTP is calculated based on FKRTL ownership, from FKRTL to FKTP, and from private FKRTL to private FKTP. In accordance with the range of estimated diabetic wound care unit rates in Table 4, IDR 67,121 to IDR 77,189, the simulated diabetic wound care unit rates for the government are IDR 65,000, and for private facilities are IDR 75,000, to calculate the potential efficiency of cost shifting from

FKRTL to primary care facilities. The results of the cost shifting analysis are presented in Tables 6 and 7.

The results of the cost-shifting simulation analysis from FKRTL to FKTP indicate that partial or complete diversion of DM wound cases can lead to substantial financial efficiency in the National Health Insurance (JKN) system. Although the main simulations in this study used 15% and 35% shifting scenarios, extrapolative illustrations for 50% and 100% shifting are also presented to show potential upper-bound efficiency gains. In the 50% case-shifting scenario from hospitals to primary care facilities, the total savings achievable are IDR 14,077,495,390, comprising IDR 10,116,443,950 in government hospitals and IDR 7,377,489,000 in private hospitals. Meanwhile, in the 100% scenario, the potential savings increased significantly to IDR 28,154,990,780, with the most significant efficiency gains from transferring cases from type B and C hospitals, which accounted for the volume of services.

Both scenarios show that the greater the proportion of DM wound cases shifted to primary care facilities, the higher the cost efficiency achieved. Therefore, this cost-shifting strategy is not only clinically feasible but also provides a strong empirical economic basis for strengthening the role of primary care facilities in managing high-cost chronic diseases, such as diabetic wounds. These scenarios demonstrate substantial opportunities for cost efficiency, serving as a key driver of enhanced overall capacity for primary care facilities. With careful implementation, this could significantly reduce the burden on the health system in the long run. The unit cost estimates derived in this study provide evidence-based inputs for developing a more rational diabetic wound-care tariff at the primary care level. Aligning FKTP payments with actual resource use is essential to prevent underprovision of services and to incentivize the management of diabetic wounds at the primary-care level rather than in hospitals.

This finding aligns with empirical evidence from several countries and highlights the growing use of TDABC to support value-based healthcare reforms [7-9,11,13,14]. In the United States, Geisinger Health System showed that a primary care-based diabetes care system could reduce total medical costs by 6.9%, with a 28.7% reduction in hospitalization costs [15]. In the UK, a comparison between enhanced primary care-based diabetes care practices and standard practices resulted in annual savings of £83 per patient [15]. Meanwhile, in Hong Kong, a primary care-based diabetes risk management program (RAMP-DM) was shown to be cost-effective and to improve clinical outcomes [15]. This study confirms that a cost-shifting approach to primary care is feasible in Indonesia as a rational strategy to control costs and improve access to healthcare services.

Practical implications

The findings of this study offer practical implications that can be directly applied within primary healthcare settings. The unit cost estimation and cost-shifting analysis indicate that diabetic wound care can be safely and effectively managed at the FKTP level at substantially lower costs. This evidence underscores the need to strengthen primary care providers' clinical competencies in wound management, ensure adequate availability of essential wound-care materials and equipment, and standardize service procedures to reduce unnecessary referrals [4,5,7]. For policymakers and BPJS Kesehatan, these results highlight opportunities to redesign care pathways, develop incentive mechanisms that promote high-quality care at the primary level, and incorporate diabetic wound-care tariffs into a more rational, cost-reflective payment structure. Implementing these changes could enhance service efficiency, reduce financial pressure on the National Health Insurance (JKN) system, and expand patient access to timely, high-quality wound care.

Limitations

This study has several limitations. First, the analysis did not consider variations in diabetic wound severity. Second, the cost calculation was independently simulated by each primary healthcare facility using TDABC tools, which may lead to variability in time and resource estimates. Lastly, the use of purposive sampling and the lack of adjustment for regional cost differences may limit the generalizability of the findings. Future studies should address these limitations by incorporating clinical variation, applying standardized time measurement, and expanding the sample across diverse healthcare settings. Additionally, the study did not distinguish between acute and chronic diabetic wounds, which may have different time and resource requirements.

CONCLUSION

The Time-Driven Activity-Based Costing (TDABC) method has proven to be an effective and practical approach for calculating service unit costs. The TDABC approach lies in its ability to reflect variations in the time and capacity of resources used, making it more precise than conventional methods [3,10]. The analysis in this study produced two tariff scenarios that reflect service efficiency levels: the minimum and realistic scenarios.

These findings are consistent with previous TDABC studies, which have demonstrated the method’s capa-

city to uncover hidden cost drivers and allocate resources more accurately [3,5,6]. The cost-shifting simulations further highlight the potential for substantial financial savings within the JKN system, amounting to approximately IDR 14 billion in the 50% scenario and IDR 28 billion in the 100% scenario.

However, this analysis has limitations because it does not differentiate between types of DM wounds and does not account for the detailed wound care authority of primary care facilities. Therefore, strengthening the role of primary care facilities in DM wound care services remains well grounded in clinical and economic evidence and should be considered in the formulation of more efficient and sustainable health financing policies. Further studies are recommended to examine the application of TDABC at the national level and across other types of primary care, to expand the empirical basis for health tariff and financing system reform in Indonesia.

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